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(54) **COMMUNICATION APPARATUS IN LABEL SWITCHING NETWORK**

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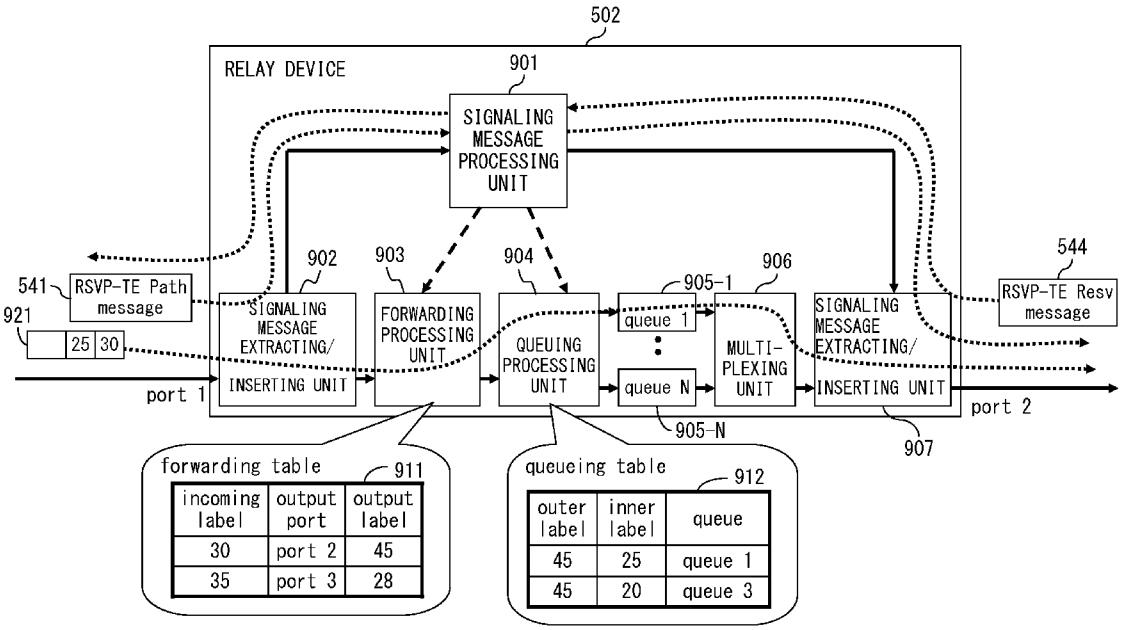
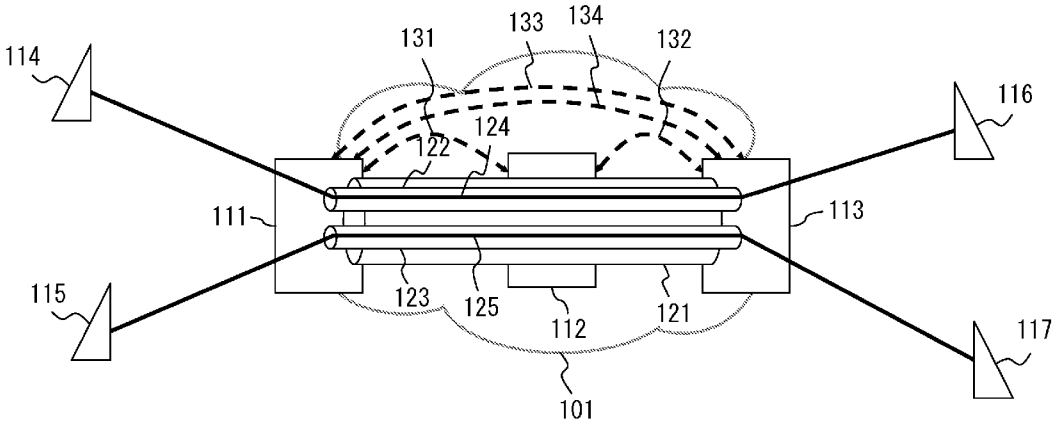
(52) **U.S. Cl.** **370/412**

(57) **ABSTRACT**

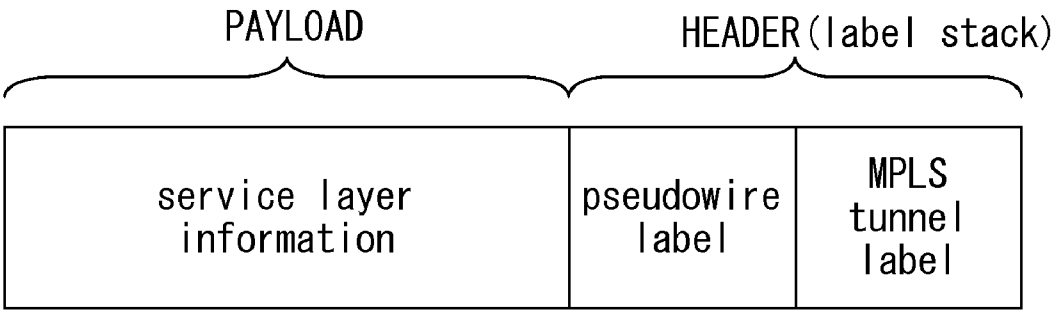
In a label switching network using a plurality of labels including first and second labels, a communication apparatus receives a packet having the plurality of labels, and determines an output destination of the packet in accordance with the first label of the plurality of labels. Additionally, the communication apparatus sorts the packet to one of a plurality of packet queues in accordance with a combination of the first and the second labels of the plurality of labels, and reads and multiplexes packets from the plurality of packet queues.





RELATED ART

FIG. 1



RELATED ART

FIG. 2

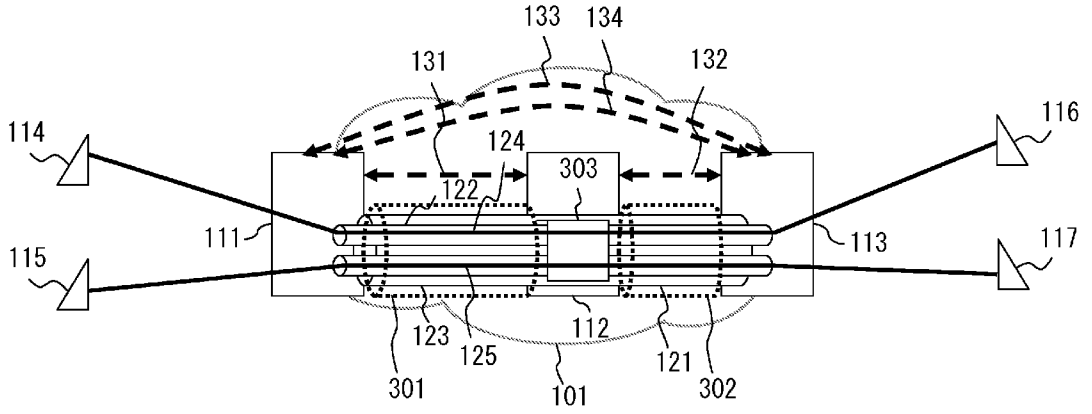

133
134
131
132
114
116
124
303
122
111
113
115
117
123
125
112
121
301
101
302

FIG. 3

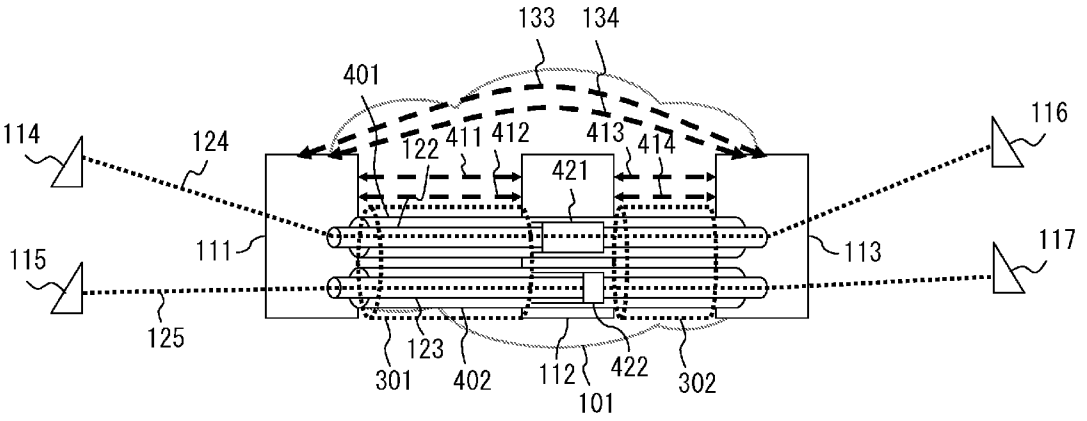
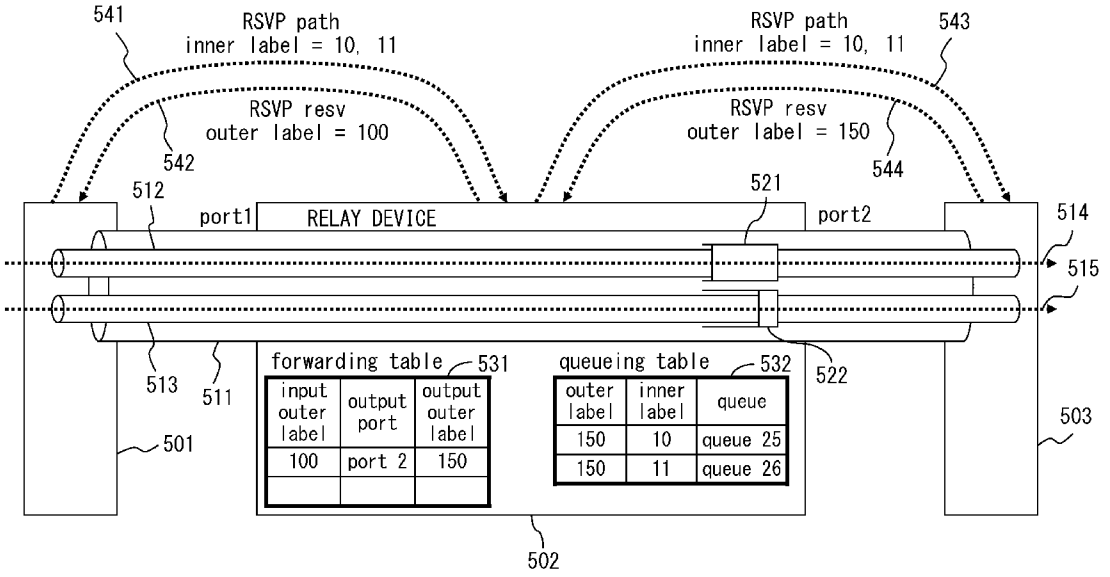

133
134
401
114
124
122
411
412
413
414
421
116
111
113
115
117
125
123
301
402
112
422
302
101

FIG. 4


541
RSVP path
inner label = 10, 11
RSVP resv
outer label = 100
542
RSVP path
inner label = 10, 11
543
RSVP resv
outer label = 150
544
512
port1
RELAY DEVICE
521
port2
514
515
513
511
522
501
forwarding table
531
input outer label
output port
output outer label
100
port 2
150
queueing table
532
outer label
inner label
queue
150
10
queue 25
150
11
queue 26
503
502

F I G. 5

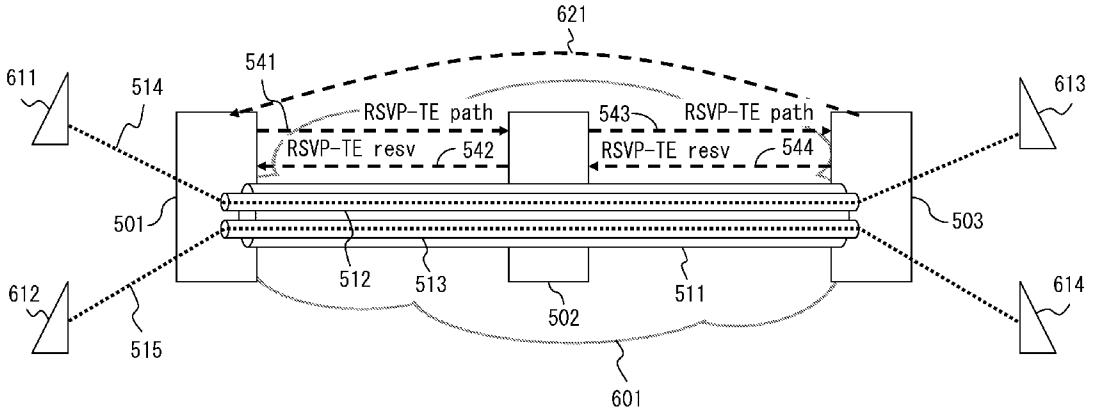

621
611
541
514
RSVP-TE path
543
RSVP-TE path
613
RSVP-TE resv
542
RSVP-TE resv
544
501
503
512
513
511
612
502
614
515
601

FIG. 6

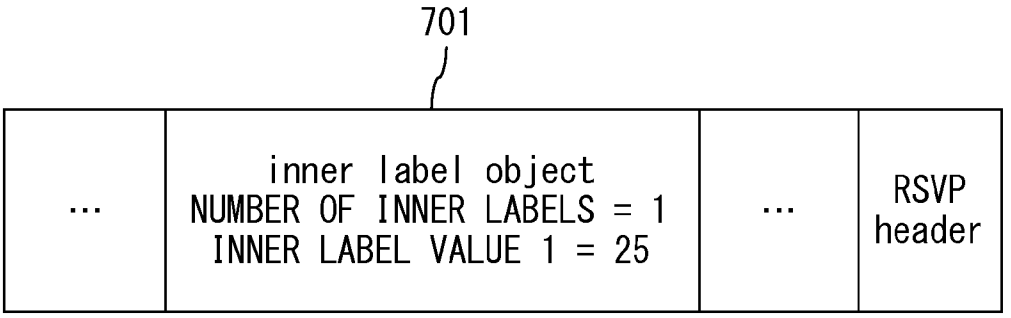

701
...
inner label object
NUMBER OF INNER LABELS = 1
INNER LABEL VALUE 1 = 25
...
RSVP
header

FIG. 7

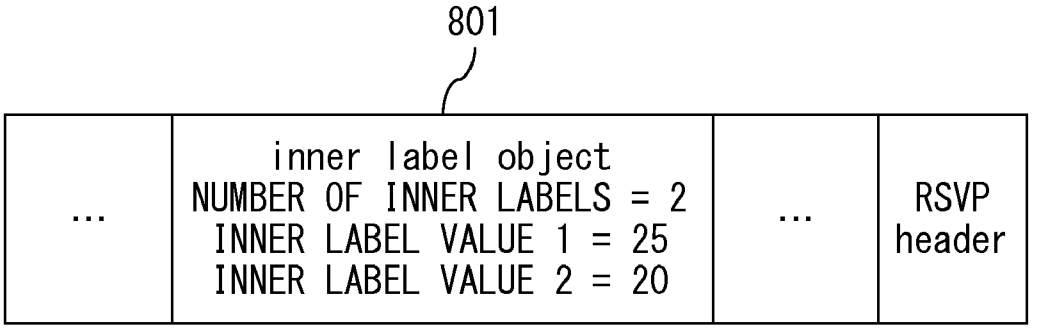
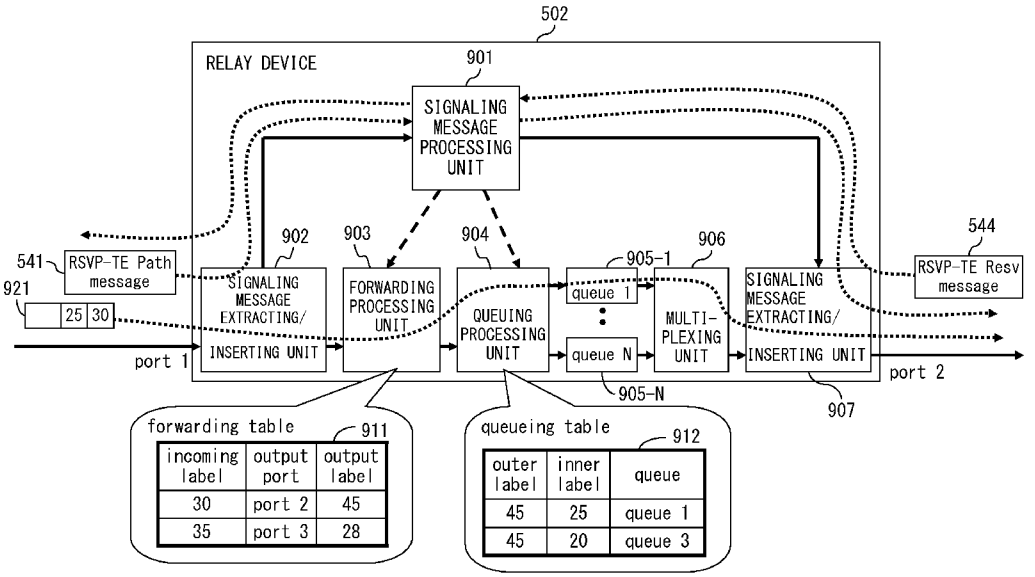

801
...
inner label object
NUMBER OF INNER LABELS = 2
INNER LABEL VALUE 1 = 25
INNER LABEL VALUE 2 = 20
...
RSVP
header

FIG. 8



incoming label	output port	output label
30	port 2	45
35	port 3	28

outer label	inner label	queue
45	25	queue 1
45	20	queue 3

FIG. 9

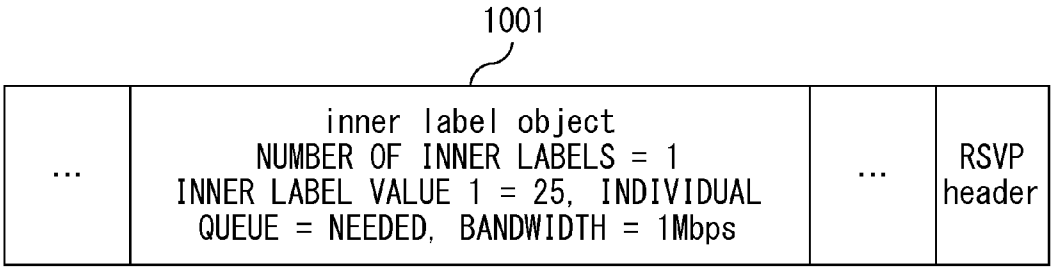

1001
...
inner label object
NUMBER OF INNER LABELS = 1
INNER LABEL VALUE 1 = 25, INDIVIDUAL
QUEUE = NEEDED, BANDWIDTH = 1Mbps
...
RSVP
header

FIG. 10

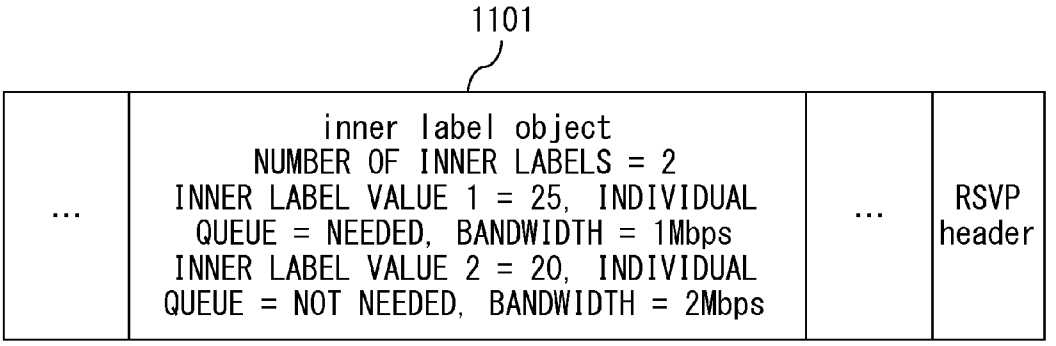

1101
...
inner label object
NUMBER OF INNER LABELS = 2
INNER LABEL VALUE 1 = 25, INDIVIDUAL
QUEUE = NEEDED, BANDWIDTH = 1Mbps
INNER LABEL VALUE 2 = 20, INDIVIDUAL
QUEUE = NOT NEEDED, BANDWIDTH = 2Mbps
...
RSVP
header

FIG. 11

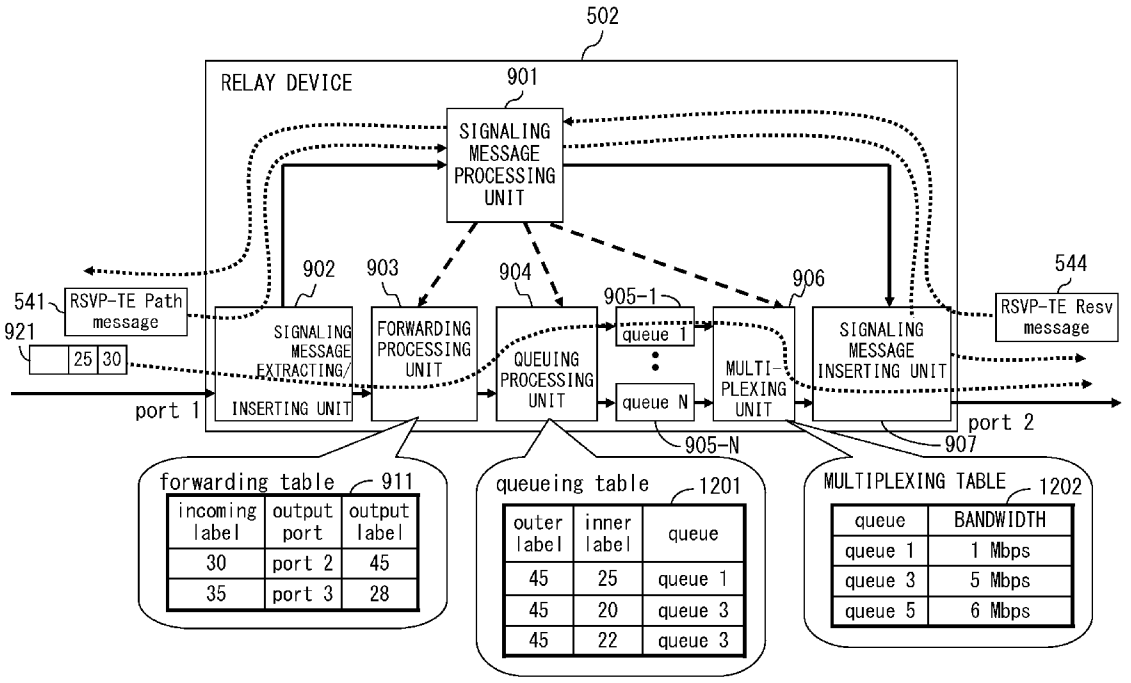

502
RELAY DEVICE
901
SIGNALING MESSAGE PROCESSING UNIT
902
903
904
905-1
906
544
541
RSVP-TE Path message
921
25
30
SIGNALING MESSAGE EXTRACTING/ INSERTING UNIT
FORWARDING PROCESSING UNIT
QUEUING PROCESSING UNIT
queue 1
queue N
MULTI-PLEXING UNIT
SIGNALING MESSAGE INSERTING UNIT
RSVP-TE Resv message
port 1
port 2
905-N
907
forwarding table 911
incoming label | output port | output label
30 | port 2 | 45
35 | port 3 | 28
queueing table 1201
outer label | inner label | queue
45 | 25 | queue 1
45 | 20 | queue 3
45 | 22 | queue 3
MULTIPLEXING TABLE 1202
queue | BANDWIDTH
queue 1 | 1 Mbps
queue 3 | 5 Mbps
queue 5 | 6 Mbps

FIG. 12

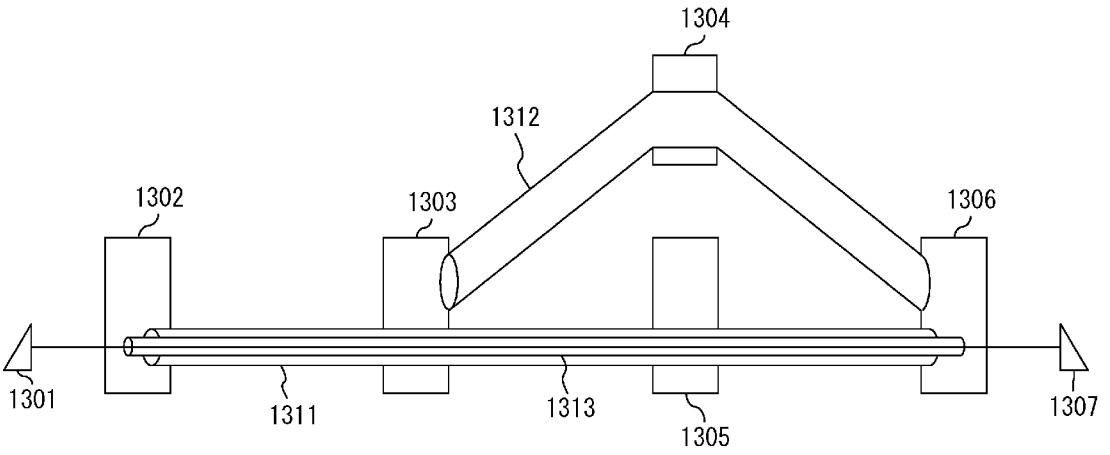


FIG. 13

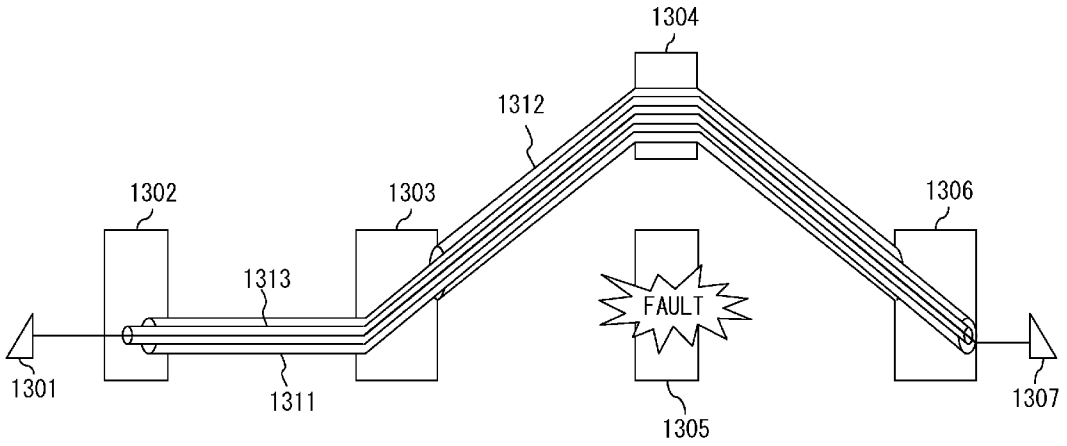


FIG. 14

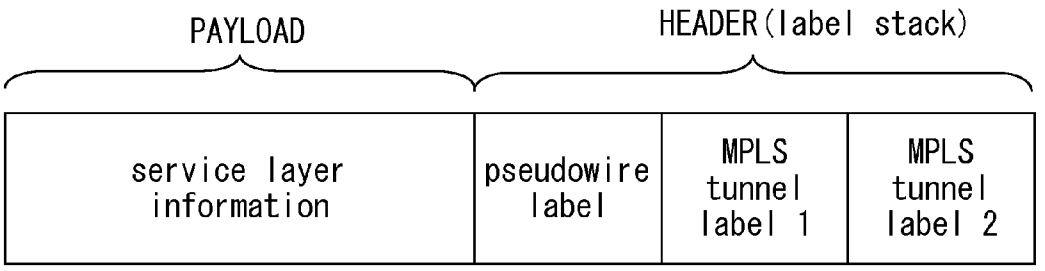

PAYLOAD
HEADER(label stack)
service layer information
pseudowire label
MPLS tunnel label 1
MPLS tunnel label 2

FIG. 15

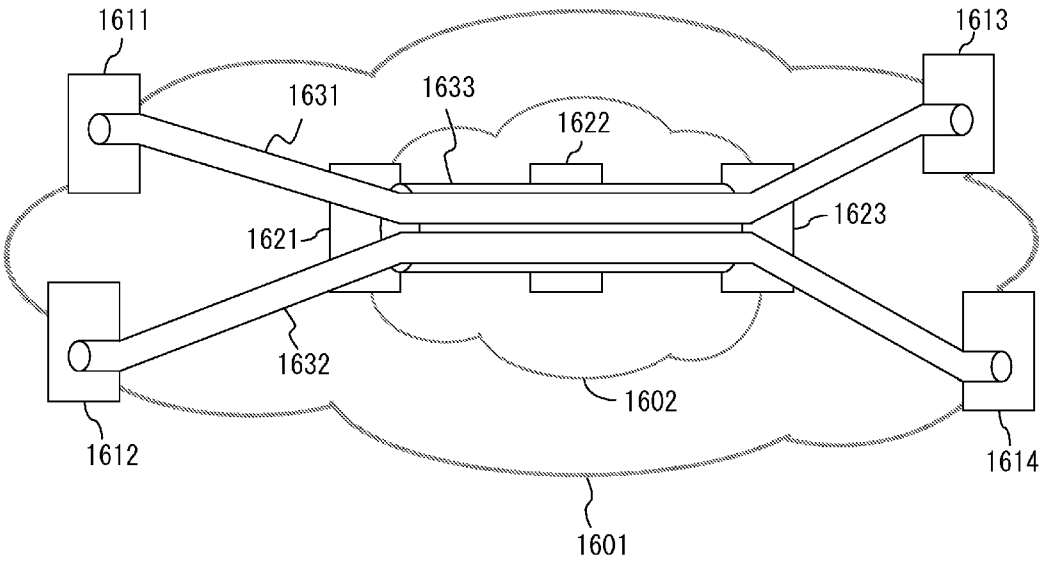


FIG. 16

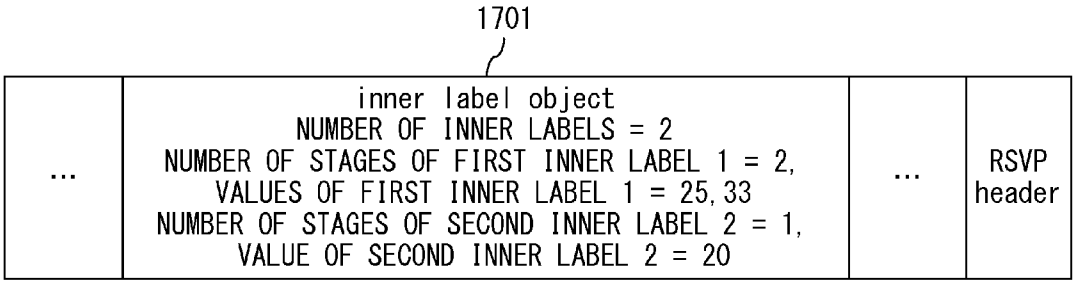

1701
...
inner label object
NUMBER OF INNER LABELS = 2
NUMBER OF STAGES OF FIRST INNER LABEL 1 = 2,
VALUES OF FIRST INNER LABEL 1 = 25, 33
NUMBER OF STAGES OF SECOND INNER LABEL 2 = 1,
VALUE OF SECOND INNER LABEL 2 = 20
...
RSVP header

FIG. 17

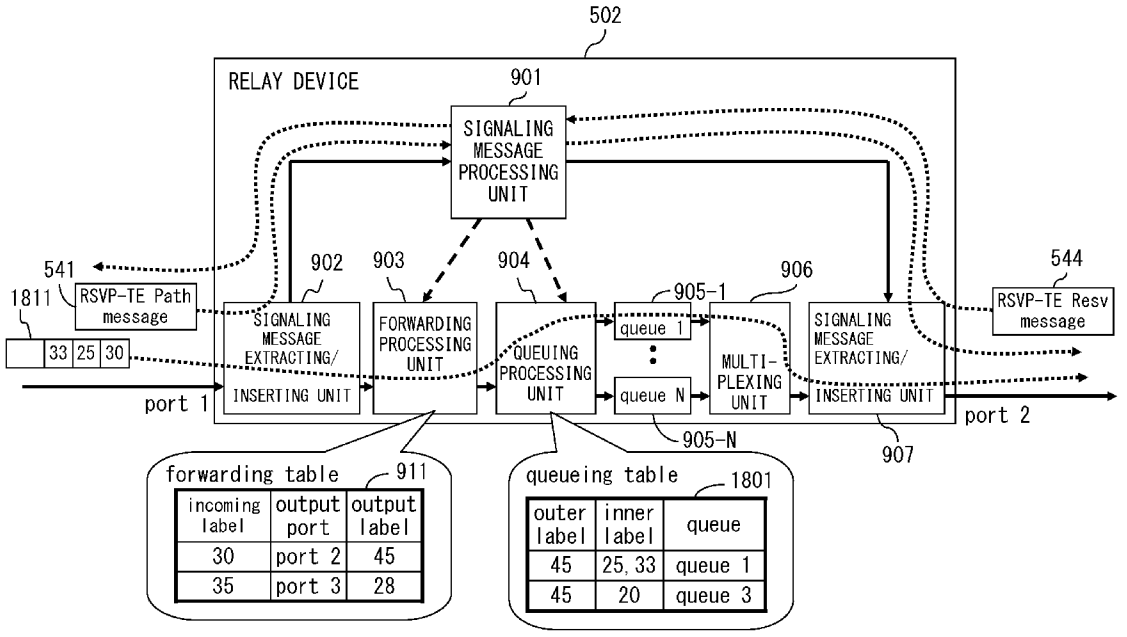

502
RELAY DEVICE
901
SIGNALING MESSAGE PROCESSING UNIT
541
1811
RSVP-TE Path message
33 25 30
902
SIGNALING MESSAGE EXTRACTING/ INSERTING UNIT
903
FORWARDING PROCESSING UNIT
904
QUEUING PROCESSING UNIT
905-1
queue 1
queue N
905-N
906
MULTI-PLEXING UNIT
SIGNALING MESSAGE EXTRACTING/ INSERTING UNIT
907
544
RSVP-TE Resv message
port 1
port 2
forwarding table
911
incoming label | output port | output label
30 | port 2 | 45
35 | port 3 | 28
queueing table
1801
outer label | inner label | queue
45 | 25, 33 | queue 1
45 | 20 | queue 3

FIG. 18

COMMUNICATION APPARATUS IN LABEL SWITCHING NETWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application of International PCT Application No. PCT/JP2007/001032 which was filed on Sep. 21, 2007.

FIELD

[0002] The embodiments discussed herein relate to a communication network and a communication apparatus which provide services by using packets each having a plurality of labels, such as a pseudo wire in a Multi Protocol Label Switching (MPLS) network.

BACKGROUND

[0003] FIG. **1** illustrates an example of a communication network that provides services by using pseudo wires (for example, see Non-Patent Document 3) in an MPLS network (for example, see Non-Patent Documents 1 and 2). Edge devices **111** and **113** in the MPLS network **101** independently provide first and second users with a first service for terminal devices **114** and **116** of the first user and a second service for terminal devices **115** and **117** of the second user.

[0004] Initially, an MPLS tunnel **121** is generated between the edge devices **111** and **113** in order to provide a transmission path for a communication made between the edge devices **111** and **113**. To generate/maintain the MPLS tunnel **121**, a signaling message **131** for the MPLS tunnel is exchanged between the edge device **111** and a relay device **112**, and a signaling message **132** for the MPLS tunnel is exchanged between the relay device **112** and the edge device **113**.

[0005] Pseudo wires **122** and **123** are set within the transmission path, which is provided by the MPLS tunnel **121**, respectively for the services in order to identify a service in the edge devices **111** and **113**. To generate/maintain the pseudo wires **122** and **123**, signaling messages **133** and **134** for the pseudo wires **122** and **123** are exchanged between the edge devices **111** and **113**.

[0006] Signals (service flows **124** and **125**) needed to provide the first and the second services are exchanged by using the pseudo wires **122** and **123**, whereby these services are provided. Here, a signal needed to provide a service depends on the type of the service. For example, for an Ethernet (registered trademark) line service that provides a communication of a Media Access Control (MAC) frame of Ethernet (registered trademark) stipulated in the Institute of Electrical and Electronic Engineers (IEEE) 802.3, the MAC frame is information needed to provide the service.

[0007] FIG. **2** illustrates an example of a packet where service layer information is encapsulated in a pseudo wire and further encapsulated in an MPLS tunnel. In this example, the service is provided by using a plurality of labels (in two stages) composed of an MPLS tunnel label and a pseudo wire label.

[0008] The MPLS tunnel label is an identifier for identifying an MPLS tunnel and is used by the edge devices **111** and **113** and the relay device **112**. The pseudo wire label is an identifier for identifying a pseudo wire and is used by only the edge devices **111** and **113**. The service layer information is a signal needed to provide the above described services. This signal is, for example, a MAC frame in an Ethernet (registered trademark) line service. The services are provided by exchanging such packets between the edge devices **111** and **113**.

[0009] In the meantime, it is desirable to multiplex a larger number of pseudo wires in one MPLS tunnel in order to provide a larger number of services in an MPLS network. The relay device forwards a packet by referring to only an MPLS tunnel label. Therefore, a forwarding table for MPLS tunnel labels which is to be held by the relay device is reduced in size by multiplexing pseudo wires. Moreover, the number of signaling messages for the MPLS tunnel which are to be processed by the relay device and the edge devices can be reduced.

[0010] The following Non-Patent Document 4 relates to Resource Reservation Protocol-Traffic Engineering (RSVP-TE) . Non-Patent Documents 5 and 6 relate to a Label Distribution Protocol (LDP) that is a signaling protocol for setting a pseudo wire. Non-Patent Document 7 relates to RSVP-TE Fast Reroute Extensions.

[0011] Non-Patent Document 1: Network Working Group Request for Comments 3031, January 2001

[0012] Non-Patent Document 2: Network Working Group Request for Comments 3032, January 2001

[0013] Non-Patent Document 3: Network Working Group Request for Comments 3985, March 2005

[0014] Non-Patent Document 4: Network Working Group Request for Comments 3209, December 2001

[0015] Non-Patent Document 5: Network Working Group Request for Comments 3036, January 2001

[0016] Non-Patent Document 6: Network Working Group Request for Comments 4447, April 2006

[0017] Non-Patent Document 7: Network Working Group Request for Comments 4090, May 2005

SUMMARY

[0018] According to an aspect of the embodiment, a communication apparatus is a communication apparatus in a label switching network using a plurality of labels including first and second labels. The communication apparatus includes a receiving unit, a forwarding processing unit, a queuing processing unit, and a multiplexing unit.

[0019] The receiving unit receives a packet having a plurality of labels. The forwarding processing unit determines an output destination of the packet in accordance with the first label of the plurality of labels. The queuing processing unit sorts a packet to one of a plurality of packet queues in accordance with a combination of the first and the second labels of the plurality of labels. The multiplexing unit reads and multiplexes packets from the plurality of packet queues.

[0020] According to another aspect of the embodiment, a communication apparatus is a communication apparatus in a label switching network using a plurality of labels including first and second labels. This communication apparatus transmits, as signaling information for generating a label switching tunnel indicated by the first label, signaling information including a value of the second label to a relay device that relays a packet communication using the label switching tunnel, and further transmits a packet having the plurality of labels to the relay device.

[0021] The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

[0022] It is to be understood that both the forgoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF DRAWINGS

[0023] FIG. **1** illustrates pseudo wires in a conventional MPLS network;
[0024] FIG. **2** illustrates a conventional packet having labels in two stages;
[0025] FIG. **3** illustrates a first queuing method;
[0026] FIG. **4** illustrates a second queuing method;
[0027] FIG. **5** illustrates a configuration of an MPLS communication system according to an embodiment;
[0028] FIG. **6** illustrates a configuration of an MPLS network according to the embodiment;
[0029] FIG. **7** illustrates a first RSVP-TE path message;
[0030] FIG. **8** illustrates a second RSVP-TE path message;
[0031] FIG. **9** illustrates a configuration of a relay device;
[0032] FIG. **10** illustrates a third RSVP-TE path message;
[0033] FIG. **11** illustrates a fourth RSVP-TE path message;
[0034] FIG. **12** illustrates a packet process using an individual queue and a common queue;
[0035] FIG. **13** illustrates a state before a fault occurs in Fast Reroute Extensions;
[0036] FIG. **14** illustrates a state after the fault occurs in the Fast Reroute Extensions;
[0037] FIG. **15** illustrates a packet having labels in three stages;
[0038] FIG. **16** illustrates a layered MPLS network;
[0039] FIG. **17** illustrates a fifth RSVP-TE path message; and
[0040] FIG. **18** illustrates a packet process using labels in three stages.

DESCRIPTION OF EMBODIMENTS

[0041] The above described conventional MPLS network has the following problem.
[0042] If one of the users utilizing the same MPLS tunnel temporarily causes a large volume of traffic to flow, this can possibly exert influences such as a delay or the like on communications made by the other users.
[0043] FIG. **3** illustrates an occurrence of such a communication delay. Assume that each committed information rate (CIR) and each peak information rate (PIR) for a communication made by each of the first and the second users is 40 Mbps and 80 Mbps, respectively. Here, the committed information rate is a bit rate that is continuously guaranteed during a communication, whereas the peak information rate is a bit rate at which packets can be transmitted while a communication network is idle. Also assume that a transmission rate (bandwidth) of a link **301** between the edge device **111** and the relay device **112** is 1 Gbps and a transmission rate of a link **302** between the relay device **112** and the edge device **113** is 100 Mbps.
[0044] Further assume that the first user causes a 70-Mbps service flow **124** to occur on a terminal device **114** and the second user causes a 40-Mbps service flow **125** to occur on a terminal device **115** in such a configuration.
[0045] The first user causes traffic to occur at a rate exceeding the committed information rate. However, since the traffic does not exceed the peak information rate, the entirety of the traffic is encapsulated by the pseudo wire **122** and the MPLS tunnel **121**, and the encapsulated traffic is transmitted from the edge device **111**. Because the traffic of the second user does not exceed the committed information rate, the entirety of the traffic is encapsulated by the pseudo wire **123** and the MPLS tunnel **121**, and the encapsulated traffic is transmitted from the edge device **111**.
[0046] The link **301** between the edge device **111** and the relay device **112** has a 1-Gbps bandwidth. Therefore, all traffic reaches the relay device **112** without any problems. The relay device **112** forwards this traffic to the edge device **113** by referring to an MPLS tunnel label. However, since the link **302** between the relay device **112** and the edge device **113** has a bandwidth as narrow as 100 Mbps, congestion occurs in the link **302**, and part of the traffic of the first user, which exceeds the committed information rate, is discarded.
[0047] This control is implemented by assigning a higher discarding priority to a packet that exceeds the committed information rate among the packets of the traffic of the first user in the edge device **111**, by transmitting this information along with an MPLS tunnel label, and by discarding a packet assigned a higher discarding priority in a device where congestion occurs.
[0048] However, the pseudo wires **122** and **123** of the first and the second users are multiplexed in the same MPLS tunnel **121**, and they have an identical MPLS tunnel label. Accordingly, when the congestion occurs due to a large volume of traffic caused by the first user and a larger delay than a packet queue **303** of the relay device **112** occurs, a large delay also occurs in the traffic of the second user.
[0049] As a method overcoming such a problem, setting each MPLS tunnel for each pseudo wire as illustrated in FIG. **4** is considered. In this case, MPLS tunnels **401** and **402** are generated respectively for the pseudo wires **122** and **123**, signaling messages **411** and **412** respectively for the MPLS tunnels are exchanged between the edge device **111** and the relay device **112**, and signaling messages **413** and **414** respectively for the MPLS tunnels are exchanged between the relay device **112** and the edge device **113**.
[0050] Here, assume that the committed information rate and the peak information rate of each of the MPLS tunnels **401** and **402** are 40 Mbps and 80 Mbps, respectively. Also assume that the committed information rate and the peak information rate for a communication made by each of the first and the second users are respectively 40 Mbps and 80 Mbps and that the transmission rates of the links **301** and **302** are respectively 1 Gbps and 100 Mbps, as in the case of FIG. **3**.
[0051] The 70-Mbps service flow **124** of the first user and the 40-Mbps service flow **125** of the second user are forwarded to the edge device **113** via packet queues **421** and **422** of the relay device **112**. Accordingly, the service flow **125** is not delayed by the congestion of the service flow **124**. However, the number of MPLS tunnels that pass through the relay device **112** in the MPLS network **101** increases with this method, leading to an increase in the number of signaling sessions to be processed by the relay device **112** in comparison with the configuration illustrated in FIG. **3**.
[0052] As described above, the relay device processes signaling sessions of MPLS tunnels by the number of services that the relay device itself relays. Therefore, a load imposed on the process for signaling messages is expected to be very heavy in the relay device that aggregates many edge devices.

Accordingly, it is impossible to increase the number of services that can be accommodated in an MPLS network to a certain number or more.

[0053] Such a problem occurs not only in a communication network where a pseudo wire is encapsulated in an MPLS tunnel but also in a communication network where the second MPLS tunnel is encapsulated in the first MPLS tunnel.

[0054] Preferred embodiments of the present invention will be explained with reference to accompanying drawings.

[0055] It is desirable to assign a different queue to each service in a relay device in order to guarantee the communication quality of each service. However, it is desirable to carry a plurality of services through one MPLS tunnel in order to hold a load imposed on a signal process for the MPLS tunnel to a low level. As a method that simultaneously satisfies these two requirements, a method for notifying a relay device and an edge device at succeeding stages of an inner label value used by each of the services within a signaling message of an MPLS tunnel and for sorting, by the relay device, a packet to a corresponding queue on the basis of the notified label value is considered.

[0056] FIG. **5** illustrates an example of a configuration of such an MPLS communication system. This communication system includes edge devices **501** and **503**, and a relay device **502**. An MPLS tunnel **511** that goes through ports **1** and **2** of the relay device **502** is set between the edge devices **501** and **503**. Additionally, a pseudo wire **512** for a service flow **514** of the first user and a pseudo wire **513** for a service flow **515** of the second user are set within the MPLS tunnel **511**.

[0057] This example assumes that RSVP-TE is used for the signaling of the MPLS tunnel. This example also assumes that an MPLS tunnel label used between the edge device **501** and the relay device **502** is "100", an MPLS tunnel label used between the relay device **502** and the edge device **503** is "150", and pseudo wire labels of the pseudo wires **512** and **513** are respectively "10" and "11".

[0058] The edge device **501** transmits an RSVP-TE path message **541** that is a signaling request of the MPLS tunnel **511** to the relay device **502**, which then transmits an RSVP-TE path message **543** to the edge device **503**. The values "10" and "11" of the pseudo wire labels transmitted through the MPLS tunnel **511** are reported within these messages. At this time, the values of the pseudo wire labels are reported using, for example, a method making the RSVP-TE path message include a new object.

[0059] The edge device **503** transmits an RSVP-TE resv message **544** to the relay device **502**, which then transmits an RSVP-TE resv message **542** to the edge device **501**.

[0060] Upon receipt of the path message **541** from the edge device **501** on an upstream side, the relay device **502** records the values "10" and "11" of the pseudo wire labels, which are reported with this message, and executes the same process as a process for a normal RSVP-TE path message.

[0061] Additionally, upon receipt of the resv message **544** from the edge device **503** on a downstream side, the relay device **502** generates a queuing table **532** on the basis of the value "150" of the MPLS tunnel label, which is reported with this message, and the recorded values "10" and "11" of the pseudo wire labels. An identifier of a corresponding queue is registered in the queuing table **532** for each combination of two values of an MPLS tunnel label and a pseudo wire label.

[0062] A packet is forwarded by using a forwarding table **531** that is generated on the basis of the values "100" and "150" of the MPLS tunnel labels, as in the conventional technology. At this time, the relay device **502** determines an output port of the packet in accordance with the value of a label in one stage at the beginning of the input packet, and rewrites the value of the label to the value of an output label. Moreover, the relay device **502** sorts the packet to a queue **521** or **522** by referring to the queuing table **532** in accordance with the values of labels in two stages at the beginning of the input packet.

[0063] With such a configuration, it is possible to provide a queue for each service accommodated in the same MPLS tunnel, whereby a delay quality of each service can be guaranteed without increasing the number of signaling sessions for the MPLS tunnel.

[0064] FIG. **6** illustrates an example of a configuration of an MPLS network including the MPLS communication system illustrated in FIG. **5**. The edge devices **501** and **503** and the relay device **502** are arranged in the MPLS network **601**. A terminal device **611** of the first user and a terminal device **612** of the second user are connected to the edge device **501**, whereas a terminal device **613** of the first user and a terminal device **614** of the second user are connected to the edge device **503**. Operations of the communication system are described below by using label values different from those of the MPLS tunnel labels and the pseudo wire labels given in FIG. **5**.

[0065] A state where only the pseudo wire **512** and not the pseudo wire **513** is set is considered as a first state. In this state, RSVP-TE path/resv messages **541** to **544** are exchanged between the edge device **501**, the relay device **502** and the edge device **503**, and the MPLS tunnel **511** heading from the edge device **501** to the edge device **503** is set.

[0066] FIG. **7** schematically illustrates an example of the RSVP-TE path message **541** transmitted from the edge device **501**. An inner label object **701** includes settings such that the number of inner labels corresponding to pseudo wire labels is "1" and the value of an inner label corresponding to the pseudo wire **512** is "25".

[0067] In this state, assume that an LDP label mapping message **621** is exchanged between the edge devices **501** and **503** and that the value of the pseudo wire label corresponding to the pseudo wire **513** is fixed to "20". At this time, the edge device **501** makes the RSVP-TE path message **541** include the value "20" of the pseudo wire label corresponding to the pseudo wire **513** in order to notify the relay device **502** that the pseudo wire **513** is also transmitted through the MPLS tunnel **511**.

[0068] FIG. **8** illustrates an example of the RSVP-TE path message **541**. An inner label object **801** includes settings such that the number of inner labels is "2" and the values of inner labels corresponding to the pseudo wires **512** and **513** are respectively "25" and "20".

[0069] At this time, the content of signaling messages for the MPLS tunnel **511** varies. Therefore, make-before-break procedures referred to in section 2.5 of Non-Patent Document 4 are used.

[0070] FIG. **9** illustrates an example of a configuration of the relay device **502**. This relay device **502** includes a signaling message processing unit **901**, signaling message extracting/inserting units **902** and **907**, a forwarding processing unit **903**, a queuing processing unit **904**, queues **905-1** to **905**-N, and a multiplexing unit **906**. Identifiers of the queues **905-1** to **905**-N are "queue**1**" to "queueN", respectively.

[0071] The path message **541** is received by the port **1**, and transferred to the signaling message processing unit **901** via the signaling message extracting/inserting unit **902**. The resv

message **544** is received by the port **2**, and transferred to the signaling message processing unit **901** via the signaling message extracting/inserting unit **907**.

[0072] The signaling message processing unit **901** generates a forwarding table **911** by processing these signaling messages, and sets the generated forwarding table **911** in the forwarding processing unit **903**. A combination of an identifier of an output port and an output label value are registered to the forwarding table **911** for each input label value.

[0073] Additionally, the signaling message processing unit **901** generates a queuing table **912** by using the value "45" of the MPLS tunnel label, which is reported with the resv message **544**, and the values "25" and "20" of the pseudo wire labels, which are set in the inner label object of the path message **541**, and sets the generated queuing table **912** in the queuing processing unit **904**. An identifier of a queue is registered to the queuing table **912** for each combination of an outer label value that indicates the value of an MPLS tunnel label and an inner label value that indicates the value of a pseudo wire label.

[0074] When the port **1** receives a packet **921** having a label stack composed of labels in two stages after these tables are set, the packet **921** is transferred to the forwarding processing unit **903** via the signaling message extracting/inserting unit **902**.

[0075] The forwarding processing unit **903** forwards the packet by referring to the forwarding table **911**. For example, if the value of the outermost label (outer label value) in the label stack of the packet **921** is "30", the label value is rewritten to "45" in accordance with the forwarding table **911**, and the packet **921** is transferred to the queuing processing unit **904** corresponding to the port **2**.

[0076] The queuing processing unit **904** sorts the packet to one of the queues **905-1** to **905**-N in accordance with the queuing table **912**. In this example, the value of the outer label in the label stack is "45", and the value of the inner label is "25". Therefore, this packet is sorted to the queue **905-1** corresponding to "queue**1**".

[0077] The multiplexing unit **906** multiplexes packets output from the queues **905-1** to **905**-N, and outputs the multiplexed packet to the port **2** via the signaling message extracting/inserting unit **907**.

[0078] Another example of operations of the MPLS communication system illustrated in FIG. **6** is described next. In this operational example, whether or not an individual queue is needed and bandwidth information are added as pseudo wire information set in a signaling message.

[0079] FIG. **10** illustrates an example of the RSVP-TE path message **541** in a state where only the pseudo wire **512** is set. An inner label object **1001** includes settings such that the number of inner labels is "1", the value of an inner label corresponding to the pseudo wire **512** is "25", whether or not an individual queue is needed is "needed", and a bandwidth is "1 Mbps".

[0080] FIG. **11** illustrates an example of the RSVP-TE path message **541** in a state where the pseudo wires **512** and **513** are set. An inner label object **1101** includes settings such that the number of inner labels is "2", the values set for the pseudo wire **512** illustrated in FIG. **10** are included, the value of an inner label corresponding to the pseudo wire **513** is "20", whether or not an individual queue is needed for the pseudo wire **513** is "not needed", and a bandwidth for the pseudo wire **513** is "2 Mbps".

[0081] As illustrated in FIG. **12**, the signaling message processing unit **901** of the relay device **502** refers to the information of whether or not an individual queue is needed set in the path message **541** and generates a queuing table **1201** with which only a packet of a pseudo wire that needs an individual queue is sorted to an individual queue and other packets are sorted collectively to a common queue.

[0082] In this example, a packet having outer and inner label values that are respectively "45" and "25" is sorted to the individual queue **905-1** corresponding to "queue**1**". In the meantime, a packet having outer and inner label values that are respectively "45" and "20", and a packet having outer and inner label values that are respectively "45" and "22" are sorted to the common queue **905-3** corresponding to "queue**3**".

[0083] Furthermore, the signaling message processing unit **901** generates a multiplexing table **1202** by using a bandwidth set in the inner label object of the path message **541**, and sets the generated multiplexing table **1202** in the multiplexing unit **906**. A read rate (bandwidth) is registered to the multiplexing table **1202** for each queue identifier. At this time, a bandwidth of "1 Mbps" set in the path message **541** is set for "queue**1**", and a bandwidth of "5 Mbps" of the common queue is set for "queue**3**".

[0084] The multiplexing unit **906** reads a packet accommodated in each queue at a rate proportional to the bandwidth of a pseudo wire while referring to the multiplexing table **1202**, multiplexes the read packets, and transfers the multiplexed packet to the signaling message extracting/inserting unit **907**.

[0085] The above described embodiment refers to the control performed when a pseudo wire is encapsulated in an MPLS tunnel. However, a similar control is applicable also to a case where a second MPLS tunnel is encapsulated in a first MPLS tunnel.

[0086] In this case, the second MPLS tunnel is nested in the first MPLS tunnel, and is transmitted through the first MPLS tunnel. Examples of the nesting of an MPLS tunnel include a case where a Fast Reroute Extensions, referred to in Non-Patent Document 7, is used, and a case where an MPLS network is layered in order to improve scalability.

[0087] The case of FRR is described first. FIGS. **13** and **14** respectively illustrate states before and after a fault occurs when the facility backup of FRR is used.

[0088] An MPLS tunnel **1311** that goes through relay devices **1303** and **1305** is set between edge devices **1302** and **1306** before a fault occurs . Within the MPLS tunnel **1311**, a pseudo wire **1313** for a service flow between terminal devices **1301** and **1307** of a user is set. Moreover, another MPLS tunnel **1312** that goes through a relay device **1304** is set to bypass the fault that has occurred in a section between the relay device **1303** and the edge device **1306**.

[0089] If the fault occurs in the relay device **1305** in this state, the MPLS tunnel **1311** is transmitted through the MPLS tunnel **1312** as illustrated in FIG. **14** in order to bypass the fault. Thereafter, a packet having labels in a total of three stages composed of MPLS tunnel labels in two stages and a pseudo wire label in one stage is transmitted between the relay device **1303** and the edge device **1306** as illustrated in FIG. **15**.

[0090] The case where an MPLS network is layered is described next. Layering of the MPLS network is used, for example, to improve scalability or the like by reducing a load imposed on a signaling or forwarding process in a core por-

tion of the MPLS network with a transmission of a plurality of MPLS tunnels through one MPLS tunnel in the core portion.

[0091] FIG. **16** illustrates an example of an MPLS network put into two layers. In an MPLS network **1601** in the first layer, edge devices **1611** to **1614** in the first layer are arranged, and an MPLS network **1602** in the second layer is included. In the MPLS network **1602**, edge devices **1621** and **1623** in the second layer and a relay device **1622** in the second layer are arranged.

[0092] An MPLS tunnel **1633** that goes through the relay device **1622** is set between the edge devices **1621** and **1623**. Moreover, an MPLS tunnel **1631** that goes through the MPLS tunnel **1633** is set between the edge devices **1611** and **1613**, and an MPLS tunnel **1632** that goes through the MPLS tunnel **1633** is set between the edge devices **1612** and **1614**.

[0093] In this example, the MPLS tunnel **1633** is set in the MPLS network **1602**, and the MPLS tunnels **1631** and **1632** in the MPLS network **1601** are transmitted through the MPLS tunnel **1633**. Accordingly, the relay device **1622** needs to process neither the signaling of the MPLS tunnels **1631** and **1632** nor an individual forwarding process for these MPLS tunnels.

[0094] For example, if a pseudo wire is further transmitted through the MPLS tunnel **1631**, a packet that passes through the MPLS network **1602** has labels in three stages as illustrated in FIG. **15**. FIG. **16** illustrates the network configuration of two layers. However, a similar control is similarly applicable to a network configuration of three layers or more.

[0095] If the number of labels is three or more, it is desirable to notify a relay device of the values of inner labels in two stages or more by using an inner label object within an RSVP-TE path message in order to guarantee the communication quality of each service. The relay device sorts a packet to a queue by referring to the labels in three stages or more on the basis of the reported information.

[0096] FIG. **17** illustrates an example of an RSVP-TE path message including an inner label object for reporting the values of inner labels in two stages. The inner label object **1701** includes settings such that the number of inner labels is "2", the first inner label is composed of the values "25" and "33" of labels in two stages, and the second inner label is composed of the value "20" of a label in one stage.

[0097] As illustrated in FIG. **18**, the signaling message processing unit **901** of the relay device **502** generates a queuing table **1801** in accordance with the configuration of inner labels set in the path message **541**. An inner label in the queuing table **1801** corresponds to one or a plurality of labels. The queuing processing unit **904** sorts a packet to a queue by referring to labels in two or three stages including an outer label.

[0098] In this example, a packet having an outer label value of "45" and inner label values of "25" and "33" is sorted to the queue **905-1** corresponding to "queue**1**". In the meantime, a packet having an outer label value of "45" and an inner label value of "20" is sorted to the queue **905-3** corresponding to "queue**3**".

[0099] For example, the outer label value of a packet **1811** is "30". Therefore, the label value is rewritten to "45" in accordance with the forwarding table **911**, and the packet is transferred to the queuing processing unit **904**. The outer label value of the transferred packet is "45" and its inner label values are "25" and "33". Therefore, this packet is sorted to the queue **905-1**.

[0100] Also, when labels in three or more stages are used, it is possible to add whether or not an individual queue is needed and to add bandwidth information as pseudo wire information set in a signaling message, as illustrated in FIGS. **10** to **12**.

[0101] All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A communication apparatus in a label switching network using a plurality of labels including first and second labels, the communication apparatus comprising:

a receiving unit configured to receive a packet including the plurality of labels;

a forwarding processing unit configured to determine an output destination of the packet in accordance with the first label of the plurality of labels;

a queuing processing unit configured to sort the packet to one of a plurality of packet queues in accordance with a combination of the first and the second labels of the plurality of labels; and

a multiplexing unit configured to read and multiplex packets from the plurality of packet queues.

2. The communication apparatus according to claim **1**, further comprising

a signaling message processing unit configured to receive, as signaling information for generating a label switching tunnel indicated by the first label, first signaling information including a value of the first label and second signaling information including a value of the second label, and to generate a queuing table to which the combination of the first and the second labels and identification information of a sorting destination queue are registered, wherein

the queuing processing unit determines a sorting destination queue of the packet by referring to the generated queuing table.

3. The communication apparatus according to claim **2**, wherein

the second signaling information includes information indicating whether or not an individual queue is needed for each second label, and

the signaling message processing unit generates a queuing table where a second label is made to correspond to an individual queue if the individual queue is needed and the second label is made to correspond to a common queue if the individual queue is not needed.

4. The communication apparatus according to claim **2**, wherein

the second signaling information includes bandwidth information of each second label,

the signaling message processing unit generates a multiplexing table to which the identification information of the sorting destination queue and bandwidth information are registered, and

the multiplexing unit reads the packets from the plurality of packet queues in accordance with the bandwidth information registered to the generated multiplexing table.

5. The communication apparatus according to claim **2**, wherein

the first label is a tunnel label of the label switching tunnel, and

the second label is a pseudo wire label of a pseudo wire generated within the label switching tunnel or a tunnel label of another label switching tunnel generated within the label switching tunnel.

6. A communication apparatus in a label switching network using a plurality of labels including first and second labels, wherein

the communication apparatus transmits, as signaling information for generating a label switching tunnel indicated by the first label, signaling information including a value of the second label to a relay device that relays a packet communication using the label switching tunnel, and further transmits a packet having the plurality of labels to the relay device.

7. The communication apparatus according to claim **6**, wherein

the first label is a tunnel label of the label switching tunnel, and

the second label is a pseudo wire label of a pseudo wire generated within the label switching tunnel or a tunnel label of another label switching tunnel generated within the label switching tunnel.

8. A communication method for use in a label switching network using a plurality of labels including first and second labels, comprising:

receiving a packet having the plurality of labels;

determining an output destination of the packet in accordance with the first label of the plurality of labels;

sorting the packet to one of a plurality of packet queues in accordance with a combination of the first and the second labels of the plurality of labels;

reading and multiplexing packets from the plurality of packet queues; and

transmitting a multiplexed packet to the output destination.

9. The communication method according to claim **8**, further comprising:

receiving, as signaling information for generating a label switching tunnel indicated by the first label, first signaling information including a value of the first label and second signaling information including a value of the second label; and

generating a queuing table to which the combination of the first and the second labels and identification information of a sorting destination queue are registered, wherein

the sorting determines a sorting destination queue of the packet by referring to the generated queuing table.

10. The communication method according to claim **9**, wherein

the second signaling information includes information indicating whether or not an individual queue is needed for each second label, and

the generating the queuing table generates a queuing table where a second label is made to correspond to an individual queue if the individual queue is needed and the second label is made to correspond to a common queue if the individual queue is not needed.

11. The communication method according to claim **9**, wherein

the second signaling information includes bandwidth information of each second label,

the communication method further comprising generating a multiplexing table to which the identification information of the sorting destination queue and bandwidth information are registered, and

the reading and multiplexing reads the packets from the plurality of packet queues in accordance with the bandwidth information registered to the generated multiplexing table.

12. The communication method according to claim **9**, wherein

the first label is a tunnel label of the label switching tunnel, and

the second label is a pseudo wire label of a pseudo wire generated within the label switching tunnel or a tunnel label of another label switching tunnel generated within the label switching tunnel.

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